



BACKGROUND

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Science and Global Climate Change: What Do We Know? What Are the Uncertainties?

About this background

In the past two decades, many scientists have raised concerns about the future of the earth's climate. In the 1970s, leading scientists raised concerns about global cooling, leading to predictions of a coming ice age. Some scientists still recognize a cooling potential.

In the mid-1980s, concern shifted to global warming, with a number of scientists stating their belief that the Earth was warming as a result of an increasing concentration of greenhouse gases in the atmosphere. Some scientists predicted dramatic increases in temperature, which would lead to the melting of polar ice-caps, rising of sea levels, and other catastrophic events. Today, after several years of investigation, many of these dire predictions have been moderated.

Global climate policy decisions must be made with the benefit of an adequate scientific understanding of the how and why of climate changes. Scientists remain divided on a number of climate change issues: Are increases of man-made gases contributing to global warming? What are the causes of global temperature change over the past century? How accurate are forecasts based on computer modeling? Are sea levels rising? How will increases in carbon dioxide (CO₂), a greenhouse gas, affect the world's plant life?

This background responds to these questions, which are being debated in the scientific community today, and provides a resource section for additional reading.

Are increases of man-made greenhouse gases contributing to global warming?

Scientists agree that the greenhouse effect is a real, naturally occurring phenomenon. Greenhouse gases trap the sun's warmth in the lowest layers of the atmosphere, keeping Earth warm enough to sustain life. Without the natural greenhouse effect the average surface temperature on Earth would fall to about zero. The earth's average temperature is about 60 degrees Fahrenheit (F), but in the natural greenhouse effect, atmospheric water vapor and clouds play a far greater role than other greenhouse gases. To put this in perspective, even if all man-made greenhouse gases were to disappear, water vapor and clouds would still leave us with almost all of the current greenhouse effect.

Scientists also agree that atmospheric levels of greenhouse gases (such as CO₂) are increasing as a result of human activity. But scientists differ on whether the increase in the concentrations of these



gases will cause an "enhanced greenhouse effect," or warming of the planet, because the role of greenhouse gases in climate change is not well understood.

As an example of this uncertainty, a recent Gallup poll of climate scientists in the American Meteorological Society and the American Geophysical Union asked whether there has been any identifiable, human-induced global warming to date. Forty-nine percent of respondents said no; 33 percent said they did not know; and only 18 percent thought some warming has occurred.

What are the causes of global temperature change over the last century?

Average surface air temperature readings appear to have increased about 1 degree Fahrenheit during the past 100 years. Just as the greenhouse effect is a natural phenomenon, so are climate cycles. While temperature records do not extend much before about 100 years ago, making it difficult to view the observed temperature change in the context of an overall trend, many scientists believe the observed increase in temperature within the last 100 years could be a result of natural fluctuations in climate. Notably, almost all the temperature increase in this century occurred before 1940, well before any significant increase in man-made CO₂ emissions.

Analysis of the temperature data records for the last 100 years are subject to several uncertainties, including the urban heat island effect, which can raise temperatures around measurement stations as urban areas expand. Urbanization increases everything from lighting to automobile exhaust and retained heat from buildings and roads. This heat island effect must be considered when looking at the long-term temperature record and explains some of the global temperature increase.

Land-based temperature records show a warm period in the 1980's but satellite measurements, which are relatively free from the distortions resulting from location, have shown no global temperature trend over the past 14 years. The satellite techniques offer the future promise of comparing observational records with global climate model projections.

How accurate are forecasts based on computer modeling?

Computer models, called General Circulation Models (GCM), are used to project future temperature and climate change scenarios. The fact is, however, that computer modeling is inexact and uncertain. Many of the world's foremost climate modelers concede that today's models can not represent the complex interactions that determine temperature and climate. At this time, modeling is unable to resolve how, where, or even whether potential global climate change can affect specific regions of the planet.

Many scientists believe current climate models are an inadequate basis for policy decisions. The manner in which these models account for water vapor (the major greenhouse gas) and cloud cover is among their greatest shortcomings. Even small modifications in these factors can dramatically alter model projections. Current climate models cannot credibly predict CO₂-induced climate changes. Today's models are only beginning to take into account the radiative effects of phenomena which counteract warming (such as sulfur dioxide emissions). The Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 by the United Nations Environment Programme and the World Meteorological Organization to evaluate the science, potential impacts and potential policies for climate change. Presenting its findings, the IPCC stated, "Climate models are only as good as our understanding of the processes which they describe, and this is far from perfect."

Are sea levels rising?

There has been a great deal of speculation about a potential sea level rise if the global climate gets warmer. Since even the most dire predictions of a warming trend would still leave the polar regions well below freezing, some scientists question the predictions of a dangerous melting of the polar ice caps.

While most scientists agree there has been some observed rise in sea level over the last century, there are questions about the accuracy of sea level measurements. Taken primarily through tide-gauge records, sea level measurements are difficult to assess because of vertical land movements, atmospheric pressure, winds, ocean currents and lunar cycles. With regard to the future, several recent studies suggest that warmer air temperatures will increase snowfall, decreasing the likelihood of sea level rise due to polar ice cap melting.

How will increases in CO₂ affect the world's plant life?

While scientists disagree on the link between CO₂ increases and any global warming, there is strong scientific evidence pointing to the link between CO₂ increases and improved plant productivity. Plant life "breathes" CO₂ as humans do oxygen. Recent studies have suggested, and many agricultural experts believe, that increasing atmospheric CO₂ levels may in fact accelerate plant growth, given adequate nutrients in the soil.

In summary

Sound policy-making rests on resolving scientific uncertainty. Focused research is critically needed to address the outstanding scientific uncertainties that surround global climate change. Although the U.S. federal research program is large, there has been debate over its focus. The usefulness of ongoing research will depend in large part on how well it can scientifically clarify answers to the questions facing both scientists and policymakers. The research must resolve the questions raised above as well as other key uncertainties such as: 1) What are the roles of cloud cover, the oceans, polar ice caps, soil and forests and their interactions? and 2) How can we differentiate natural climate variations from changes attributable to man-made emissions? If the research fails to address these and other issues, the result may be stacks of good scientific articles, but little progress in translating data into information that policy makers can use to make effective decisions.

Recommended Reading

Boettcher, C.J.F. Science and Fiction of the Greenhouse Effect and Carbon Dioxide. The Hague, Netherlands: The Global Institute for the Study of Natural Resources, 1992. (Copies are available through the Science and Environmental Policy Project at 703-527-0130.)

Houghton, J.T., Jenkins, G.J., ed. Climate Change: The IPCC Scientific Assessment. Cambridge University Press, 1990.

Houghton, J.T., Jenkins, G.J., Ed. Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment. Cambridge: Cambridge University Press, 1992.

Singer, Fred S., ed. The Greenhouse Debate Continued: An Analysis and Critique of the IPCC Climate Assessment. San Francisco: ICS Press, 1992. (Copies are available from ICS Press at